FIELDS OF SCIENCE AND ENGINEERING

Knowledge from the following fields of science and engineering is used in carrying out the programs of the Naval Weapons Laboratory. Although the Laboratory does not offer work on major programs in every one of these fields, it is interested in discussing employment opportunities with persons who have training, experience or interests in any of them.

Aeronautics

- Aerodynamics
- Aeronautics
- Aircraft (Vulnerability to Weapons)

Astronomy

- Astronautics
- Astronomy
- Celestial Mechanics

Atmospheric Sciences

- Atmospheric Physics
- Meteorology

Biological Sciences

- Microbiology
- Weapon Effects

Chemistry

- Chemical Engineering
- Inorganic Chemistry
- Organic Chemistry (Explosives and Propellants)
- Physical Chemistry

Earth Science and Oceanography

- Dynamic Oceanography
- Geodesy (Satellite)
- Physical Oceanography
- Satellite Mapping
- Underwater Sound

Electronics and Electrical Engineering

- Components
- Computers
- Electronic and Electrical Engineering
- Guidance and Control (Missiles)
- Information Theory
- Instrumentation
- Shipboard Systems
- Radar
- Telemetry

Materials

- Ceramic Engineering (Fiberglas)
- Metallurgy and Metallography

Mathematical Sciences

- Algebra

Continued overleaf

SCIENTISTS AND ENGINEERS

U. S. Naval Weapons Laboratory
Dahlgren, Virginia

The staff of the Naval Weapons Laboratory includes scientists and engineers in the following professions:

- CHEMISTRY
- ENGINEERING
  - Aerospace
  - Chemical
  - Electrical
  - Electronic
  - General
  - Mechanical
- MATHEMATICS
- OPERATIONS RESEARCH
- METALLURGY
- METEOROLOGY
- MICROBIOLOGY
- PHYSICS
- STATISTICS

The Laboratory is interested in persons having qualifications in related disciplines and sub-disciplines (see back cover of pamphlet).

FIELDS OF SCIENCE AND ENGINEERING

The purpose of this pamphlet is to inform you, as a possible applicant for employment, of those areas of science and engineering in which the programs of the Naval Weapons Laboratory lie and to describe the types of work being done in the major areas.

In the following pages you will find descriptions of positions in:

- Chemistry and Chemical Engineering
- Electronics for Physicists and Engineers
- Mechanical Engineering and Engineering Mechanics
- Mathematics
- Mathematical Statistics
- Operations Research
- Physics

If your profession is not covered, or if you desire to know more about what we are doing in areas of special interest to you, we would like to receive your inquiry. The address is: Industrial Relations Department, U. S. Naval Weapons Laboratory, Dahlgren, Virginia 22448.

A comprehensive list of the fields of science and engineering used in the Laboratory is given on the back cover. Although we do not offer work on major programs in every one of these fields, we are interested in discussing employment opportunities with persons who have training, experience or interests in any of them.

ELECTRONICS FOR PHYSICISTS AND ENGINEERS

The vital role of electronics in modern military operations involving weapons, communications and computers is reflected in the place this discipline has in the activities at NWL.

Instrumentation: Design and develop electrical and electronic instrumentation systems, including setup and operation of equipment to evaluate its accuracy and efficiency. For example, physicists and engineers will design and evaluate automatic calibrating circuits for use with temperature, pressure, and force transducers.

Electromagnetic Effects: Design and conduct both shipboard and laboratory tests to determine the effects of electromagnetic radiation on electroexplosives and other electrically actuated ordnance devices. Conduct tests on attenuating materials and devices developed to eliminate the above effects. Design, install, and operate equipment required in these tests. This work involves measurement of frequency, power, impedance, pulse rate, and signal strength in the microwave region.

Study, design and evaluate radio-frequency measurement techniques and equipment. Includes measurements of intensity and power density required in radio-frequency interference studies and in evaluation of the hazards of radio-frequency fields to personnel.

Computer Engineering: Electronic or electrical engineers, or physicists with a background and interest in electronics, conduct research and development projects in the general field of information processing engineering. This work is carried on in the environment of a major computing laboratory which utilizes the most powerful available equipment in the solution of many types of engineering, scientific, and other problems. Specific projects may include the development or modification of complete information processing systems, special devices, or components; evaluation of the effectiveness of differing system configurations for various classes of operations; assessment of the potential performance of advanced systems based on the performance of research stage components; or the development of troubleshooting techniques to suit special requirements. Types of equipment involved in these projects include very high speed general purpose digital computers (such as the IBM 7090, 7030, 360/40, and NORC), special data acquisition and conversion facilities, communications interface and switching equipment, special peripheral and auxiliary devices (including remote terminal and display systems), and special purpose digital systems for fire control applications.

Electromagnetic Compatibility: Conduct analyses and design and conduct experiments to determine interference effects of electromagnetic radiation on fire control radars, missile guidance receivers, telemetry receivers, and other electronic components of weapon systems. Develop and utilize instrumentation for monitoring and recording shipboard and aircraft electromagnetic environment levels and modulation characteristics. Conduct laboratory evaluations of developmental circuits and components to determine basic compatibility characteristics.

MECHANICAL ENGINEERING AND ENGINEERING MECHANICS

Engineers at NWL find opportunities to participate in the entire range of research and development activities. In the programs described below, engineers, with scientists of other disciplines, participate in exploratory and engineering development programs, as well as experimental and evaluation studies of relations between design performance and environment. NWL seeks engineers with the capacity to conceive and execute designs, balancing performance with safety, reliability, producibility and maintainability, and with an understanding of the value of computer assistance in engineering trade-off analyses.

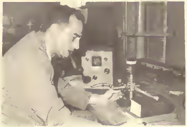
Prototype components for power cartridges are developed.

Cartridge Actuated Devices: Assist in the development of ordnance components for emergency ejection of personnel from aircraft, missile launching, missile separation and other applications. Duties are concerned with the selection of explosive, metallic and plastic materials, detail design, prototype fabrication and experimental ballistic tests. Knowledge of strength of materials, thermodynamics, kinematics, shock phenomena in solids, and electrical circuits is desirable.

Warheads and Terminal Ballistics: Make analytical studies of problems involving terminal ballistic performance characteristics of missile or warhead components, comparing various design options. Plan and execute development programs. Plan and manage experimental programs to evaluate suitability, reliability, and operating characteristics of missile components.

Missile Safety and Performance Evaluation: Assist in the design, development, and testing of systems and procedures which lead to the improvement of shipboard missile system safety and performance. Work involves current shipboard and air-launched weapon systems and also includes basic tests of advanced propellant systems. Duties include preparation of reports and other documents on tests conducted.

Analyze safety problems associated with the handling of containers filled with hazardous chemicals. Design handling equipment and other devices to overcome hazardous conditions. Develop standards for the design and construction of chemical containers and handling systems.



The attenuation of signal strength in a lossy line is studied.

PHYSICS

Physicists at NWL are engaged in many areas of investigation associated with weapons and the naval environment. Although a few projects are carried on by a single investigator, small teams (often interdisciplinary) of two to six scientists are usually employed. Typical areas of work are described below.

Propulsion and Energy Conversion: Exploration of physical factors in the field of rocket propulsion and cartridge actuated devices, for example, pilot escape systems. Typically, a series of single parameter estimates are derived relating each of several performance properties with each of several initial conditions. Special conditions or optima are sought. Background and training should be in classical physics. Applicants should be able to handle problems in mechanics, heat, and thermodynamics of gases.

Detonation and High Pressure Physics: Theoretical and experimental research on explosive effects, such as fragmentation, blast, shock, detonation waves, shaped charge effects, and damage. The objective of the research is the formulation of laws of the basic mechanisms of explosive effects by means of which new and improved warheads and defenses against warheads may be designed and constructed. Academic preparation in thermodynamics, mechanics and hydrodynamics is desirable.

Exterior Ballistics and Geoballistics: Research and development in all areas of exterior ballistics and geoballistics, e.g., studies of the flight stability of missiles and generation of aiming data for all the Navy's armaments including the Fleet Ballistic Missile System. Extensive use is made of mathematical simulation models in conjunction with the Laboratory's digital computing equipment.

Instrumentation: Research in physics of measurement involving both laboratory and field experiments incident to the design and development of transducers and measurement techniques. Investigations are conducted to determine the magnitude of errors to be expected in the use of transducers and systems for making dynamic measurements.

Studies include correlating the characteristics of air shock and rocket exhaust with their effects on structures and weapon components. Responsibilities also include planning and operation of electronic instrumentation systems to obtain appropriate data during rocket firing programs.

Electromagnetism: Research on the effects of electromagnetic radiation of electroexplosive and other electrically actuated devices in ordnance. Physicists formulate, analyze and evaluate experiments designed to measure the above effects and the degree of protection afforded by materials and devices developed to eliminate these effects.

Molecular Vibration: Theoretical studies of molecular vibration spectra, fluorescent phenomena, bioluminescent phenomena, gas and paper chromatography, and associated areas of physics with the objective of developing techniques for detecting and identifying trace quantities of material in the atmosphere.

Astronautics: Perform research on the theory of satellite orbits and in the field of celestial mechanics. Methodology is developed for analyzing extensive sets of observational data on satellites in order to determine precisely their orbits. Studies of satellite orientation and methods of stabilizing satellites are made. Research is conducted in geodesy, use being made of satellite data to advance the knowledge of the geoid and of methods for the precise location of worldwide sites.

MATHEMATICS

One of the largest groups of mathematicians in the Navy's laboratories is located at NWL. Assignments range from the applied work necessary in development programs to research in mathematics, especially in the field of numerical analysis, and the development and utilization of computer programming systems. Mathematicians have available one of the major digital computing centers in the nation.

Mathematical Models and Simulations: Develop and apply mathematical models and simulations in a number of areas, including:

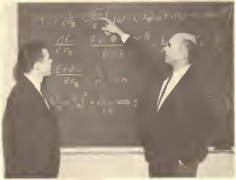
Astronautics
Warfare Analysis
Exterior Ballistics
Geoballistics
Systems Effectiveness Studies

The use of such models is an essential function in the research, development, test and evaluation of weapon systems. In this work mathematicians are frequently teamed with physicists or engineers. Through these assignments mathematicians develop the ability to use large digital computers as tools to solve major scientific and engineering problems.

Research in Applied Mathematics: Conduct research in applied mathematics, largely in the field of numerical analysis. Also, research is directed toward developing more powerful methods for the use of large digital computers. Problems in astronautics, for example, require solving for thousands of unknowns on the basis of millions of satellite observations.

Computer Programming: Develop and implement advanced computer languages, processors and systems. Mathematicians develop improved methods of programming and coding problems for computers, as well as the preparation of specific programs. The programmers work in close cooperation with analysts, participating in the conception of the program and applying their knowledge of computer capabilities, numerical techniques and related matters. The Laboratory trains mathematicians for work in this field.

Research in Mathematical Physics: Conduct research, frequently in cooperation with physicists, in a variety of areas of mathematical physics, *e.g.*, fluid dynamics, celestial mechanics, and hydrodynamics. The Computation Center provides these scientists with a powerful research tool.

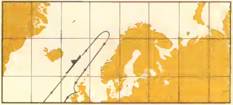


Mathematicians discuss a formulation used in a study of target motion.

MATHEMATICAL STATISTICS

The statistician at NWL works in three major areas: (1) the application of statistical methodology to the development and evaluation of naval ordnance systems, (2) research in statistical theory, and (3) the development of large-scale computer programs for statistical analyses. Specifically, he designs and analyzes physical experiments, simulated computer experiments and sampling surveys, and he develops acceptance sampling procedures for naval ordnance components. The basic research is generally related to existing or anticipated needs in the Laboratory's programs. At present such research is being done in the areas of multiple regression techniques and the orthogonal and nonorthognal analysis of variance and covariance.

Research projects and the development of computer programs alike are stimulated by actual problems at NWL and by the availability in the Laboratory of powerful computing equipment. New statistical methods for data analyses, suitable exclusively for large-scale computers, are constantly being developed. With the use of such methods, it is possible, for example, to solve satisfactorily the problem of analyzing classifications of observed data with many missing values.



The deployment of the Fleet Ballistic Missile System is studied by operations research analysts.

OPERATIONS RESEARCH

The Laboratory applies a major capability in operations research and analysis to a wide variety of Navy problems. The extensive computing facilities of the Laboratory constitute a powerful tool for this work. Two important programs are described below:

Warfare Analysis: Assist in carrying out broad studies related to naval operations, using mathematical simulation techniques. Such factors as weapon system performance, logistics, and the movement of aircraft, surface ships, and submarines are included in the studies for the purpose of analyzing the interaction of opposing forces. The simulation and analysis of amphibious operations, from the standpoint, for example, of the adequacy of proposed plans and hardware, constitutes a major program.

Strategic and Tactical Weapon Systems Analysis: Carry out research on the methodology of optimizing fleet deployment and in such allied fields as target assignment, operational area optimization, and determination of the relations of a deployed force and a target system. Provide operational guidelines and analysis assistance to fleet planning staffs and participate in the Navy's long range strategic system development program. In connection with the development and evaluation of strategic systems, carry out target analyses, determine casualty or damage probabilities, evaluate target intelligence, and determine the interactions between warheads and targets. Participate in similar research related to the development and evaluation of tactical weapon systems, including nuclear, high explosive, biological warfare and chemical warfare systems.

CHEMISTRY AND CHEMICAL ENGINEERING

In addition to actively carrying on research in propellant and pyrotechnic chemistry in support of the Cartridge Actuated Devices Program and maintaining an analytical service laboratory, chemists and chemical engineers at the Naval Weapons Laboratory are constantly seeking solutions to challenging problems which occur in many parts of the Laboratory's technical programs. The following are indicative of the kinds of work in which the Laboratory is engaged:

Materials: Analyze safety aspects of the stowage, handling, and operational use of liquid propellants and other toxic, corrosive and hazardous chemicals and agents. Conduct experimental research and theoretical analysis to provide information for the selection of appropriate and compatible materials for safe use in weapon systems.

Select compatible materials and design containers and transfer units to handle extremely hazardous and corrosive chemicals. Conduct research with the objective of developing self-sealing liner materials for use in chemical containers.

Electrochemical Interactions: Design, analyze, and evaluate tests to determine the effects of electromagnetic radiation on electroexplosives and other electrically actuated devices in ordnance. Furnish technical advice on the chemical properties of explosive initiators and, with the assistance of physicists and electrical engineers, determine and predict the effects of subjecting electroexplosives to electromagnetic radiation. Assist in the preparation of test reports and publications on the handling, use, and storage of ordnance in electromagnetic fields.

Chemists and chemical engineers are also employed in research on detectors, decontaminants and materials for use in chemical warfare.

FIELDS OF SCIENCE AND ENGINEERING

(Continued from back cover)

Mathematical Sciences (Cont.)

- Analysis
- Information Processing
- Logic
- Operations Research
- Statistics
- Theory and Practice of Computation
- Weapon Systems Evaluation

Mechanical Engineering

- Applied Mechanics (Ordnance and Ballistics)
- Containers and Packaging
- Instrumentation and Control
- Safety Engineering (Weapon Systems)
- Weapon Design and Development

Military Sciences

- Antisubmarine Warfare
- Chemical, Biological and Radiological Warfare
- Defense
- Intelligence
- Logistics
- Nuclear Warfare
- Operations, Strategy and Tactics

Missile Technology

- Missile Launching
- Missile Trajectories
- Missile Warheads and Fuzes

Navigation, Communications, Detection and Countermeasures

- Communications
- Electromagnetic Countermeasures
- Navigation and Guidance
- Radar Detection

Nuclear Science and Technology

- Isotopes
- Radioactivity
- Weapons Effects

Ordnance

- Ammunition, Explosives and Pyrotechnics
- Bombs
- Combat Vehicles (Vulnerability)
- Explosions, Ballistics and Armor
- Fire Control and Bombing Systems
- Guns and Projectiles
- Rockets
- Underwater Ordnance

Physics

- Acoustics
- Crystallography
- Electricity and Magnetism
- Fluid Mechanics
- Flight of Missiles
- High Pressure Phenomena
- Lasers
- Physical Metallurgy
- Plasma Physics
- Solid-state Physics
- Thermodynamics
- Wave and Shock Propagation

Propulsion and Fuels

- Rocket Motors and Engines
- Rocket Propellants

Space Technology

- Astronautics
- Space and Re-entry Trajectories